Calibration of an Air Pollution Measurement System

Neiza M. Hernández Cordero
GCEP/SURE 2000
Environmental Research Division
Argonne National Laboratory

Abstract

Atmospheric chemistry has to be understood, because the contamination of the atmosphere is increasing. There are several types and effects of air pollution, which are commonly, discussed, the ozone hole, smog, acid rain, the greenhouse effect and automobile emissions. My research this summer focused on ozone, carbon monoxide, ultraviolet radiation, nitrous gases and particles. During this summer at Argonne National Laboratory, the calibration of a nephelometer and instruments that measure NOx, CO, O_3, UV was carried out. Data was collected over a two-week period to test out the instruments. The instruments are presently in Deer Park, Texas as part of the TNRCC field experiment.

Abstract (cont.)

The following graphs show the data taken from July 12th to July 30th. As expected we saw that when the O_3 went up the NO goes down. Ozone typically increased after sunrise as it is produced by a photolytic reaction. The inlet line to the instruments was placed near a loading dock and we were able to study truck emissions. The first field data from Houston is also presented.

Introduction

Humanity has become increasingly worried about the pollution of the earth, specially the air. Air supplies us with oxygen, which is essential for our bodies to survive. Human activities have released substances into the air, some of which can cause problems for humans, plants and animals. An air pollutant is anything that affects the composition of the air including carbon monoxide, nitrogen oxides and particles. Ozone depletion is one of the results of pollution. Ozone forms a layer in the stratosphere. It is created when sunlight (ultraviolet radiation) strikes the stratosphere, dissociating oxygen molecules to atomic oxygen. The atomic oxygen quickly combines with other oxygen molecules to form ozone.

Introduction (cont.)

Stratospheric ozone also absorbs a lot of the harmful UV-B radiation. The decrease in the amount of stratospheric ozone is causes by chlorofluorocarbons (CFCs) increasing the intensity of solar ultraviolet radiation reaching the ground. We measure the ultraviolet radiation not only because it causes skin cancer and has damaging effects on plants and wildlife, but because it dissociates NO_2 in the troposphere. The oxides of nitrogen, NO and NO_2, play an important role in air pollution. The principal source of nitrogen oxides is the combustion of fossil fuels. When NO and NO_2 are present in sunlight, ozone formation occurs as a result of the photolysis of NO_2,

Introduction (cont.)

$$NO_2 + h\nu \rightarrow NO + O$$

$$O + O_2 + M \rightarrow O_3 + M$$

Once formed O_3 reacts with NO to regenerate NO_2,

$$O_3, + NO \rightarrow NO_2 + O_2$$

This cycle is a closed loop and by itself would not generate large concentrations of ozone. Hydrocarbon radicals can convert NO to NO_2 without using any ozone, allowing ozone concentrations to increase. Troposphere ozone can cause lung damage such as bronchitis and asthma. The U.S. EPA implements programs to reduce the concentrations of ozone. Carbon Monoxide (CO) is another pollutant that affects human health. The principal

Introduction (cont.)

source of carbon monoxide in the urban areas is motor vehicles. Is a product of incomplete combustion and occurs when carbon in the fuel is partially oxidized. Carbon monoxide reduces the flow of oxygen in the bloodstream and is particularly dangerous to persons with heart disease. Particles are so small, they remain suspended in the air where they can be inhaled and deposited deep in the respiratory system. Particles are associated with respiratory symptoms, cardiopulmonary disease, lung cancer and asthma. As well as causing health damage, particles can lead to major reductions in visibility.

Instrumentations

NO/ NO_2/NOx Analyzer- Model 200AU

- Applications:
  - Measure the concentration of :
    - ✓ Nitric oxide NO
    - ✓ Nitrogen dioxide NO_2
    - ✓ Total oxides of nitrogen NOx
  - Measures the light intensity of the chemiluminescent gas phase reaction of nitric oxide and ozone.

Instrumentations (cont.)

Series1008 U. V. Photometric Ozone analyzer

- Applications:
  - Measurement the concentration of ozone in ambient gas, such as air, O_2, N_2, etc.
  - It is accomplished by measuring the absorption of ultraviolet light.

Instrumentations (cont.)

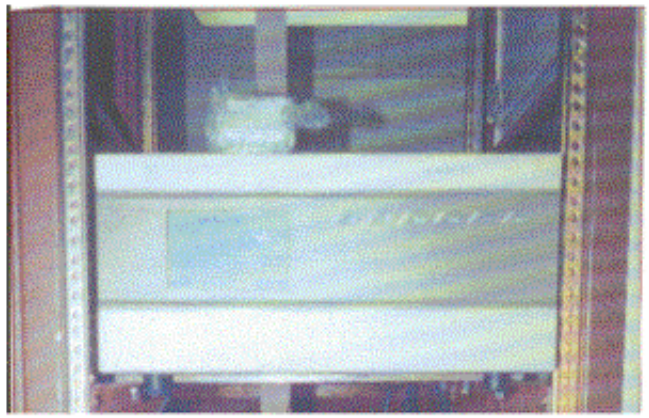
UV-Biometer Model 501A

- Applications:
  - Measurement of biologically effective ultraviolet radiation (UV-B) from sunlight.

Instrumentations (cont.)

ML 9830 Carbon Monoxide Analyzer

- Applications:
  - Is a non-dispersive infrared photometer that accurately and reliably measures low concentration of CO, using gas filter correlation.
  - Absorbs infrared radiation (IR) at wavelengths near 4.7 microns; therefore the presence and the amount of CO can be determinate by the amount of absorption of the IR.

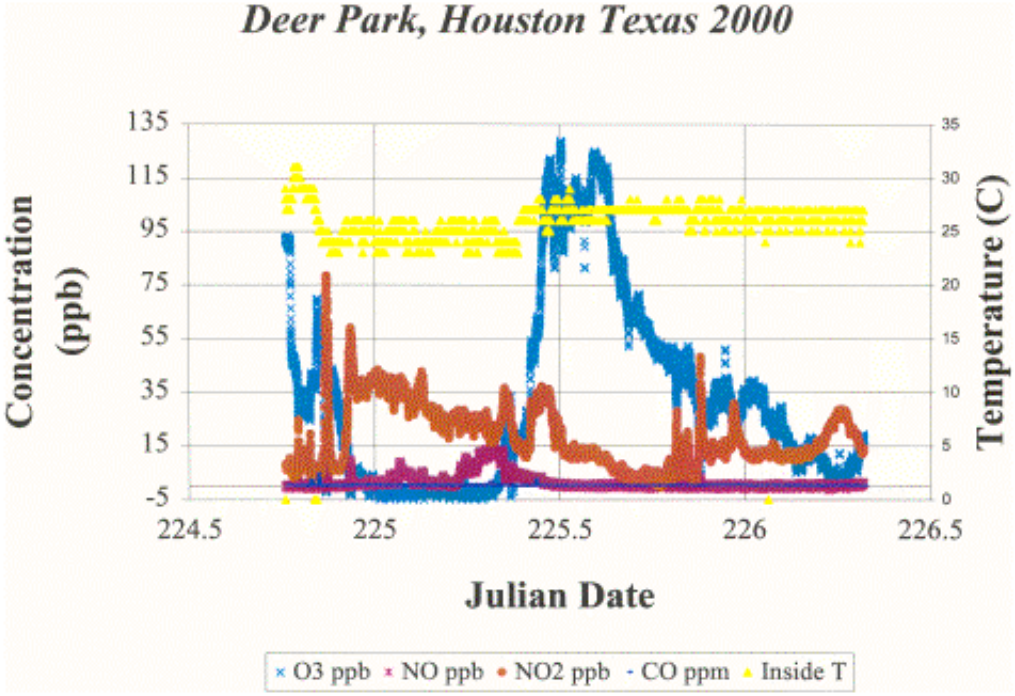


Instrumentations (cont.)

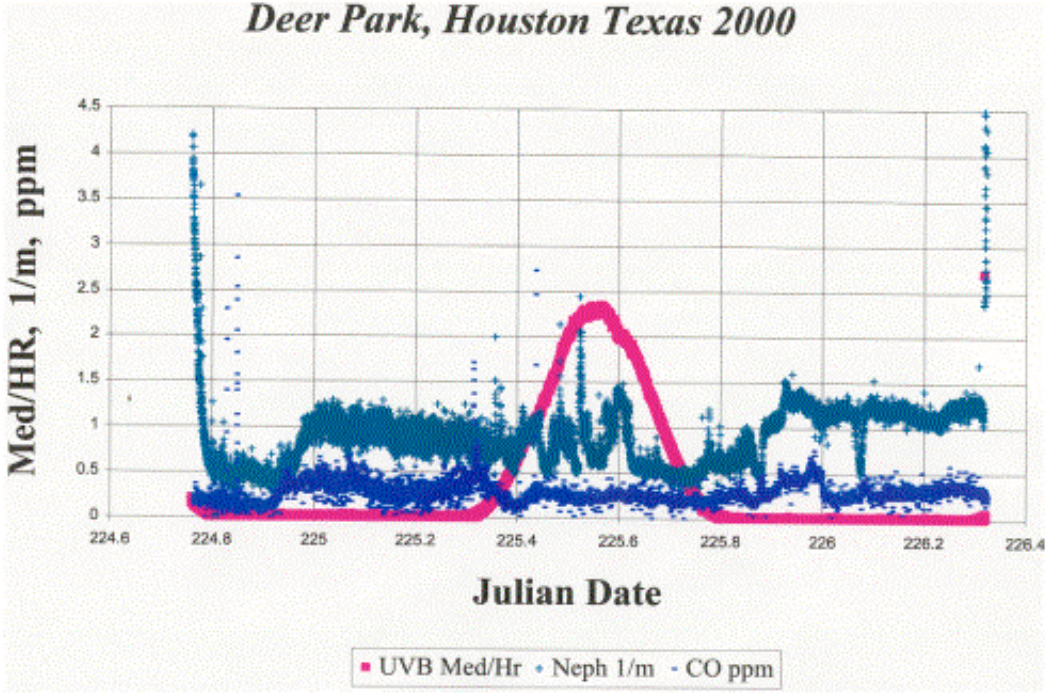
Nephelometer

- Applications:
  - Measure the scattering extinction coefficient, the sum of molecular and particles scattering.
  - This coefficient is a useful parameter for estimating visual range and fine particles mass loading.
  - Measure the visibility in the air.

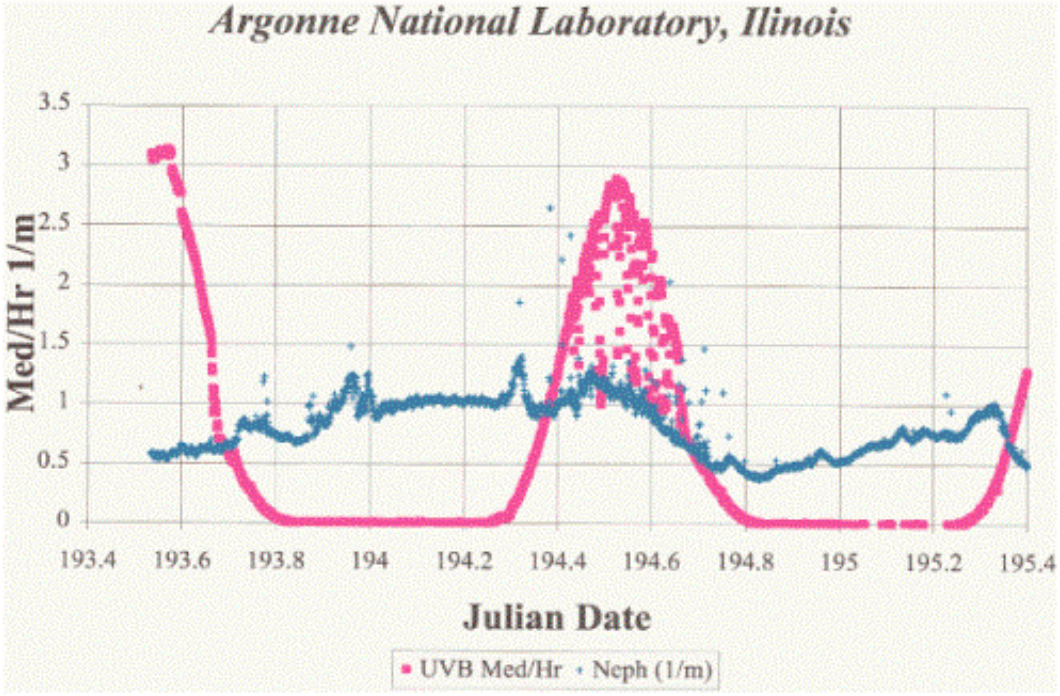
Data Analysis



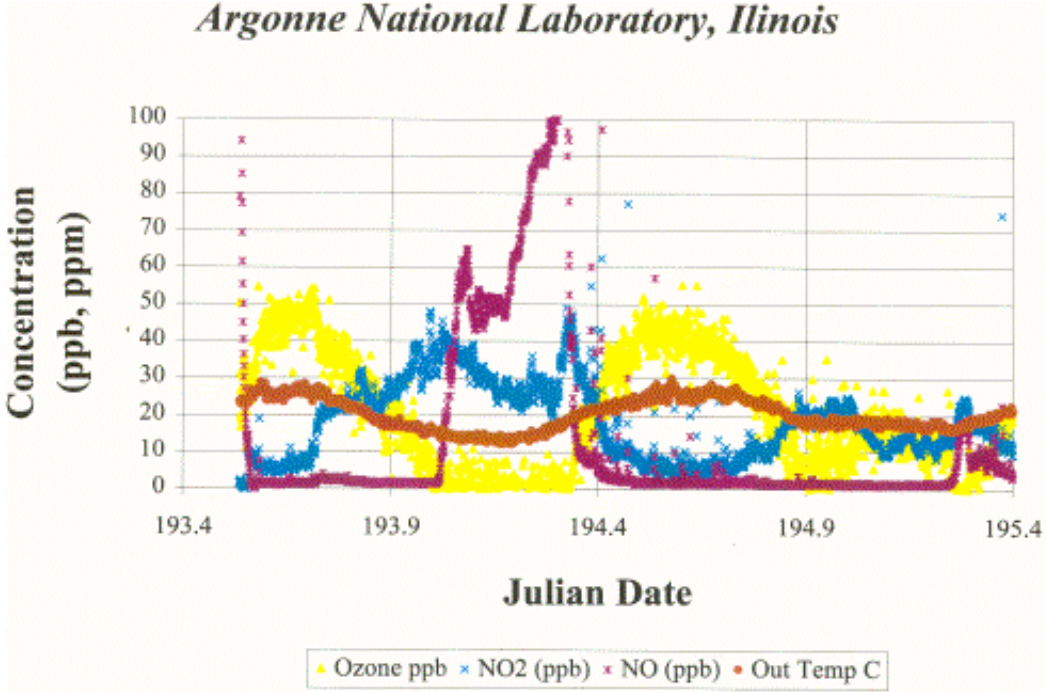
Data Analysis (cont.)



Data Analysis (cont.)



Data Analysis (cont.)



Conclusion

During this summer I learned about the importance of air pollution and the chemistry happening throughout the atmosphere. The objectives of my research were to familiarize myself with instruments that measure air pollutant and to find out how air pollution affects the environment in which we live. After installing the instruments in the trailer, we proceeded to calibrate them. Then, we started to take data and analyze it. The results that we observed were as expected. Data was collected in Argonne National laboratory. We observed that when ozone went up the NO goes down, that happens because the ozone reacts with NO

Conclusion (cont.)

to give NO_2. Also we observed that the ultraviolet radiation at nighttime is zero. Particles in the air are in the same range, but sometimes increase.Now the instruments are presently running in Deer Park, Texas taking data. Data from Deer Park was presented.

Future Work

Puerto Rico has many features that are interesting for scientists in the atmospheric chemistry area. A field study, in Puerto Rico is planned for 2002. The purpose of my summer research was to increase my understanding of air pollution instruments. In this way, I can help in site preparation and the installation of the instruments in 2002, Puerto Rico. A preliminary study will take two ozone instruments down to and take data from Mayagüez and Río Piedras.

Acknowledgments

First, I want to thank God for giving me the opportunity. Paul, thanks for all the patience during my summer session and for your help in this poster. I feel very grateful to the people of GCEP for helping me during this experience: my mentors Dr. Jeff Gaffney and Dr. Nancy Marley; Milton Constantin, Mary Kinney, Pat Shoulders, Dr. Tim Martin and Dr. Paul Doskey. I would like to thank the people that believed in me and helped me during this summer experience.